PHOTOLUMINESCENT DIAMOND NANOPARTICLES

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The Nitrogen-Vacancy [N-V] colour centre in diamond, consisting of a substitional Nitrogen atom associated to a Vacancy in an adjacent lattice site, has fascinating luminescence properties like its photostability at room temperature [1]. NV color centers can be efficiently produced by high-energy electron or ion irradiation of diamond crystallites followed by thermal annealing [2].

Nevertheless, strong limitation of defect photoemission in diamond arises from the high index of refraction of the bulk diamond material which makes difficult an efficient extraction of the photoluminescence. Refraction at the sample interface leads to a small collection solid angle, limited by total internal refraction, and to strong optical aberrations. An efficient way to circumvent these problems is to consider the emission of defects in diamond nanocrystals, which size is much smaller than the wavelength of the radiated light [3] (see figure-a). The sub-wavelength size of the nanocrystals renders refraction irrelevant and one can then simply assimilate the embedded color defects as point sources radiating in air.

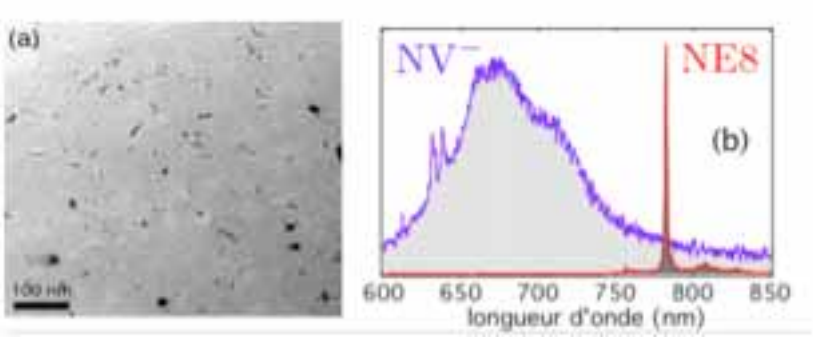

Figure : (a) TEM image of diamond nanocrystals dispersed on an electronic microscope grid (see Ref. [3]). Angular shape of most of the nanocrystals is due to crushing in the fabrication process leading to diamond powder suited for abrasive applications. Irradiation with an electron beam of the powder induces formation of N-V color centers in the nanocrystals. (b) Photoluminescence spectra of a single N-V color center and a single Nickel-related defect. The two spectra are recorded respectively with laser excitation at 532 nm and 687 nm wavelength (see Ref. [12]).

Photoluminescent nanodiamonds have a wide range of applications, going from quantum optics to biotechnology. At the single-emitter level which can be reached by appropriate irradiation dose, they are remarkable sources for producing single-photon light pulses on demand [4]. They have been used to implement single-photon quantum key distribution within realistic operating conditions [5] and to observe single-photon interference [6,7]. Diamond is also a biocompatible, non toxic and chemically inert material [8]. Since the surface of nanoscale diamond particles can be chemically functionalized with for instance carboxyl groups [9], luminescent nanodiamonds can be envisioned for targeted drug delivery in biotechnology.

The wide variety of color centers in diamond also offers an unique opportunity to optimize the photoluminescence properties [10]. Recently, Nickel-related point defects in diamond arose strong interest. These defects can be found in some natural type II-a diamonds and also in high-pressure high-temperature diamonds where Nickel is used as a solvent/catalyst for

the crystal growth. Compared to the broadband NV colour centre emission (approximately 100 nm centered around 700 nm), the photoluminescence of individual Ni-related colour centre has several striking features [11,12]: a narrow band emission around 800 nm almost entirely concentrated in the zero-phonon line (ZPL), corresponding to a spectral width of the order of 1 nm (see figure-b); a nanosecond excited-level lifetime ; and a linearly polarized light emission. It was also shown that these color centers can be fabricated in a controlled way inside chemical vapor deposited (CVD) diamond thin films [13]. Such diamond defect control opens numerous possibilities and I will report the observation of individual Ni-related color centers in well isolated CVD-grown nanodiamonds.

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